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PLAGUE IN INDIA, PAST AND PRESENT: A CONTRAST

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It is interesting and profitable to contrast our present knowledge of plague, precise, accurate and practically useful as it is, with the ideas that prevailed among medical men before the advent of the dread disease to India in 1896.

Plague had not visited the plains of Hindustan for many years, and was only known traditionally as a disease that had devastated armies and towns in pre-sanitary times; and had come to be regarded as of interest only to antiquarians and historians, and as of no practical importance to the ordinary medical man. It was therefore with surprise, and even incredulity, that the announcement of the presence of the bubonic plague in Bombay was received in October, 1896. As the epidemic spread through the city one realised the truth of many of the tales of terror handed down from the past. The railway stations were besieged by thousands flying from this nameless terror, which the strongest measures of the authorities seemed powerless to control. The scenes witnessed by those whose

business took them to the plague-infested parts of the city were heartrending beyond description. Streets deserted, whole families found dead with no record to tell who they were or where they came from, mothers lying cold with helpless babies beside them whom no one dared pick up to take care of, from fear of this new and terrible disease. Business came to a standstill, the inhabitants fled to the country, and it became very difficult to obtain even domestic servants.

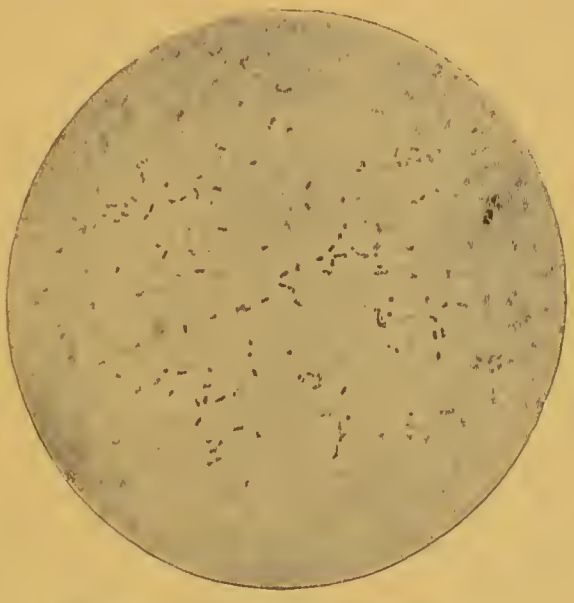
That the Government had done their best was evident. Within a fortnight of the advent of plague they had summoned Mr. Haffkine, the well-known bacteriologist, to their aid, and formed a committee of medical men to devise means of combating the disease, and had done as these had advised; yet all their efforts were in vain, because of the ignorance that then prevailed as to its way of spreading, and therefore of the proper measures to take to arrest its progress.

Thousands of pounds were wasted on disinfectants, which experiment has since shown are utterly useless, and innumerable lives were lost through ignorance of the proper precautions to adopt. As panic passed off, the Government established laboratories and organised bands of medical men whose business it was to study the disease: but it was only after years of observation and of laboratory experiments that it was discovered how plague really spreads.

As time went on, and epidemic succeeded epidemic, it gradually came to be realised that the principal agent in the start and spread of plague among men was the rat. "No rats, no plague" passed into a sanitary by-word, and the common people came to regard dead rats as a species of omen, and a warning to quit the houses where they were discovered. For it was found

that when dead rats appeared, unless the inhabitants vacated a place, sooner or later plague would become epidemic among them.

It was noticed that the infection hung about huts where these dead rats had been found, and that persons visiting such huts for even a short time frequently acquired the disease. It was also observed that people flying from an infected to an uninfected place were often the means of starting an *epizootic* among the rats



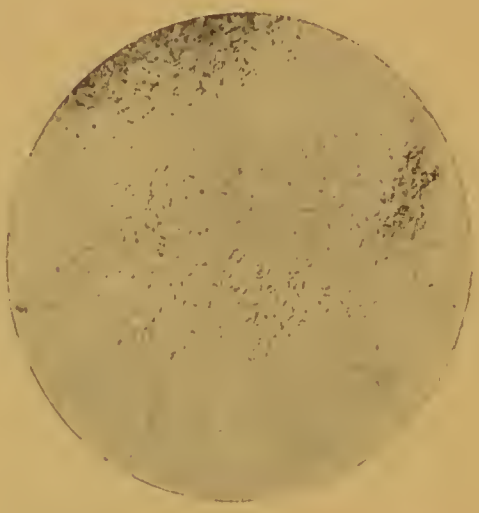
Plague Germs in Blood of Rat × 850.

of the place to which they had fled, and so originating an *epidemic* among the people a little while afterwards, though they sometimes escaped themselves. Experience likewise proved that the common form of plague was not infectious in the ordinary acceptation of the term, for the attendants and relatives of patients did not acquire the disease from the sick. How could these things be explained?

The Plague Commission sent out from England in

1898 at the request of the Indian Government came to the conclusion that the infection of plague always entered through the skin.

About the same time, a French observer made experiments which tended to incriminate the flea, though the results of his researches were by no means conclusive. A young officer of the Indian Medical Service was, however, so convinced, by a study of the facts brought to light by the experiences of successive



Smear from the Stomach of an infected Rat Flea magnified about 850 times.

epidemics, that there was something in this theory, that he proceeded to study the rats of Bombay and the insects parasitic upon them. He discovered that the flea found on rats is of a different species from that infesting man, but that if the rats were removed by disease or otherwise, their fleas would take to man and feed upon him. He discovered by experiment that fleas fed on plague-stricken animals contained plague germs in their stomachs in a living state, and that the germs

freely multiplied there. He likewise found that a proportion of the guinea-pigs he exposed to the bites of these inseets developed plague, and died of it. So important did these experiments and observations appear, that permission was obtained from Government to build a series of small rooms on the model of those in Bombay eity, in which to carry on experiments on a large seale. At this stage in the investigations, the Government of India appointed a second Plague Commission, eomposed of bacteriologists from the Lister Institute associated with an equal number from the Indian Medieal Serviee.

Before commeneing work they carefully reviewed all the faets already found out eoneerning plague and its spread, and arrived at the conelusion that rats were probably responsible for the spread of the disease in India. From a eonsideration of the work noted above, they were inelined to think that the flea might be the means of transmission from rat to man, and accordingly devised experiments to establish or controvert this view. There were, however, two other ideas eoncerning plague infeetion that had to be investigated as well, namely : (*a*) that rats might soil food by their exereta, and that people eating sueh eontaminated food might in this way be infeeted ; or (*b*) that rats might similarly infeet the floors of dwelling-houses and that the inhabitants, who mostly walk barefoot in their dwellings, might thus be infected.

The first hypothesis was disproved by the results of a series of experiments in whieh rats were fed on the careases of their relations which had died of plague. It was found that only when an overwhelming dose of this material was given did infection oeeur, and that feeding on food mixed with excreta from plague-

infected rats or patients failed to induce the disease. Further, as the result of post-mortem examination of 6,000 rats which had died of plague naturally contracted in Bombay city, it was found that buboes (plague-swellings) were never present in the abdominal cavity, as would have been the case had the infecting germs entered by the route of the stomach or intestine.

On the contrary, all the plague buboes were in glands connected with the skin, through which evidently the germs had gained an entrance.

The second hypothesis, that contaminated floors were dangerous, was a favourite one in the early days of plague in India, and very naturally so when one considers the habits of the people, who go about without shoes, and eat their food seated on the floor. Experiment quickly disposed of this idea, however, for it was found that animals penned on floors grossly contaminated with plague germs did not acquire plague except where actual pools of plague culture were on the floor—a condition which would never occur in Nature. It was likewise found, when experimenting with plague-infected huts, that just as many guinea-pigs contracted plague when placed in rooms that had been washed out with strong disinfectant acid solution of perchloride of mercury, as in similar rooms not so treated. It is well-known to all sanitarians that acid perchloride of mercury will kill effectually all germs in places thus treated, so it was plain that the infection in these rooms did not reside in the floors.

Thus the Commission ascertained that neither contaminated food nor soil was the agent responsible for the spread of plague in India.

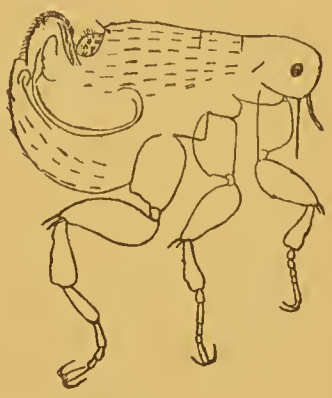
We may now turn to consider the experiments made to determine whether the flea is the real transmitter of

plague from rat to rat and from rat to man. In the early days of this investigation, before the Commission arrived in India, it was frequently pointed out that no one took plague in hospital, though plenty of fleas were to be found there. This seemed fatal to the flea hypothesis, till it was shown that the flea found in hospital was not the rat-flea, but one which is never found on rats. It was manifestly impossible, therefore, that these human fleas could become infected from the plague rats. On the other hand, it may be asked "If

♂ Pulex cheopis

Rat Flea.

♂ Pulex irritans



Human Flea.

human fleas are not found on rats, are rat-fleas ever discovered on men?" As the investigation proceeded, it was discovered that though the natural host of the rat-flea is the rat, yet, in the absence of rats, the rat-flea will resort to other animals, and even man himself, for shelter and food. The absence of rats may be brought about by death from plague. It is a well-known fact that rats dead from plague are dangerous to man shortly after death, but not when cold some hours afterwards. Why? Because the fleas remain on the body only as long as heat remains, and desert it when

it is cold. A recently-dead rat is, therefore, covered with fleas, but one which has become cold has none. A striking illustration of this was furnished by a house in Bombay where some hundred people lived in a number of small rooms. Rats died in the tenement, and living rats disappeared. Two days after, the inhabitants were so troubled with fleas that they had to forsake their rooms and sleep in the verandahs. A few days more, and plague appeared among them. A search for fleas on the people revealed the interesting fact that a large proportion of the capture were rat-fleas, and that some of them contained plague germs in their stomachs. In the light of the fuller knowledge that subsequent experiment on animals threw on this series of events, it is easy to understand what happened in this crowded tenement. First, plague among the rats; secondly, death and disappearance of the rats; thirdly, starvation of the fleas; fourthly, attack of the people by the fleas, some of which were infected; fifthly, development of plague among the people.

It having been proved that rat-fleas are in certain circumstances found on man, it became necessary to determine whether they can transmit plague itself. A glass box was made, large enough to contain a couple of wire cages in which rats or other animals might be confined. The glass box was covered in by muslin, so as to make it insect-proof. Each animal cage stood in a tray filled with sand to absorb the discharges; so that no possible communication could take place except through the air, or by some insect capable of passing from one cage to the other.

Into one of the cages was put a rat artificially infected with plague, and along with it ten to twenty rat-fleas. When this rat died a healthy one was placed

in the other cage contained within the same glass case. Eight hours after, when its body was cold, the corpse of the first rat was removed and examined to make quite certain that it had really died of plague.

If the healthy rat in the second cage died subsequently, it was also examined to determine the cause of death. When the experiment was performed as above described with English rats, especially imported so as to ensure that they had not previously been exposed to plague infection, in eleven out of sixteen experiments the healthy rats contracted plague. To exclude the possibility of aerial infection, another series of trials was made by putting fleas from plague rats into a glass box similar to the above, but containing only one healthy rat. In eight out of thirteen experiments made with English rats, the flea-bitten rat died of plague.

Having ascertained in this and other ways that it is an easy matter to infect susceptible animals by means of fleas taken from plague-infected animals, the next step was to find out whether close contact of infected animals with healthy ones was, in the absence of fleas, capable of starting an epizootic.

For this purpose the experimental rooms already described were utilised. These were constructed in such a manner as to be flea-proof, and all animals placed in them were carefully searched to make sure that no fleas were introduced accidentally.

Fifty guinea-pigs were put into one room measuring seven by six feet, and then ten others artificially infected with plague were added. The room was purposely not cleaned out, so that in a few days the animals were living in most insanitary conditions. As the infected guinea-pigs died of plague the bodies were left for twenty-four hours before removal, so as to afford

every chance for contagion to play its part. Yet not one of the fifty healthy animals died. Many other similar experiments were performed in that and subsequent years, always with the same result: not a single healthy guinea-pig contracted plague.

A parallel series of experiments was conducted in rooms which were kept well supplied with rat-fleas. One such may be cited. Five plague-infected guinea-pigs were placed in a room: in three days all had died of plague. After the last of the bodies had been removed, twenty-five healthy guinea-pigs were put in and allowed to run about freely. An epizootic at once broke out amongst them, and all had succumbed in a fortnight. Fleas were present in great numbers throughout this experiment. These fleas, on being transferred to a room where fifty guinea-pigs had been living for three weeks, started an epizootic among them which in six weeks killed them all from plague.

In these rooms it was likewise ascertained that animals suspended at more than the height of a flea's jumping powers above the floor invariably escaped plague, while those suspended in cages into which fleas could jump were liable to contract it.

The next step was to find out if plague houses were dangerous because of the fleas they contain. This was effected by allowing guinea-pigs to run free in rooms from which plague cases had been removed to hospital. After twenty-four hours the guinea-pigs were exposed to the fumes of chloroform. The stupefied fleas which then fell off them could easily be picked up and counted. Two facts emerged: viz. (*a*) that nearly all the fleas were rat-fleas and that they were present in great numbers; (*b*) that a large number of the guinea-

pigs thus allowed to run free in these rooms developed plague.

Another series of experiments made in the plague-infected rooms of the city showed that the flea, and not either the floor or the wild rats in the rooms, was the causative agent. For this purpose pairs of cages containing animals were used, one contrived so as to exclude fleas, and the other open to their entrance; while both were made so as to protect the caged animal from contact with the floor or rats that might visit the room during the night. This was accomplished by a wall of fine wire gauze or by a six-inch-wide surrounding of "Tanglefoot" fly-paper, wide enough to catch any fleas trying to approach the animal in the cage. In 122 such experiments none of the protected animals contracted plague, while seventeen (14 per cent.) of the unprotected succumbed to that disease. Of 401 fleas caught on the "Tanglefoot" papers, 55 per cent. were rat-fleas; 37 per cent. were human fleas; and 8 per cent. were cat-fleas. Plague bacilli were demonstrated in the stomach contents of one out of 85 human fleas, and in twenty-six out of 132 rat-fleas dissected.

If rooms are infective because they contain rat-fleas, one would expect to find such fleas more numerous in plague-infected than in healthy dwellings, and this was the case.

Thus, in 1907, the houses observed in Bombay were divided into three classes: (*a*) those known to be plague-infected; (*b*) those presumably plague-infected; (*c*) those known not to be infected.

On comparing the numbers of fleas caught by the guinea-pigs "traps" in these classes of rooms, it was found that those certainly infected furnished nearly three times the number of fleas that those only

presumably infeeted did, and twelve times the number that uninfeeted rooms did.

The eonclusions derived from the above are that the rat-flea is the means of conveying plague from one animal to another, that the rooms are dangerous because of the infected fleas in them, and that the soil and air have no infeective properties.

These conclusions being granted, we must go a step further and eonsider what evidenee exists to show that the rat-flea is the cause of the transmission of plague from rat to man, and that it also is responsible for the spread of the disease from one plaee to another. It is of course impossible to bring forward aetual proof of this, as one eannot experiment on man as on animals. But one ean use the monkey for this purpose ; and few persons will be found able to resist the eonelusion that if the flea is able to transmit plague to the monkey, then a man plaeed in like circumstanees would contraet it likewise. By experiment, the Commission showed that monkeys are just as liable to be infeeted in the experimental rooms as guinea-pigs, and that when exposed in eages in plague-infected plaees, a regular proportion of them contraet plague. It may, therefore, reasonably be inferred that man exposed similarly to the bites of infeective fleas would contract the disease in this manner. That bubonie plague enters through the skin was affirmed by the first Plague Commission on the ground that buboes (lymphatic glands swollen by the irritation of the plague germs) develop in proportion to the extent of skin which is related to the affeeted glands. These conelusions were amply eonfirmed by observing what happened after infeeted fleas had been fed on definite areas of the skin of guinea-pigs. In praetically every ease the primary bubo was found in the nearest

lymphatic gland, which had of course become infected from the plague germs introduced at the spot where the flea had bitten. It has likewise been noticed that races wearing boots have just as great a proportion of groin buboes in their plague cases as the bare-footed Indians.

Now we have already seen that one of the first objections that had to be removed, before the flea-transmission theory could be thought of, was the fact that rat-fleas are not ordinarily found in houses or on the bodies of men. We have seen how the discovery was made that when rats disappear they leave behind multitudes of rat-fleas, which when pressed by hunger will attack man or any animal that can afford them the blood they require for food. Incidentally during the carrying out of the numerous experiments, it was noticed that the man who had to enter the room to feed the animals confined there, would emerge with his bare legs covered with rat-fleas, and it was the regular practice to station somebody outside, with a pledget of cotton soaked in chloroform, with which to kill the fleas on the man's legs.

If now we grant that plague infection reaches man by the route of the skin, then we must look for some pricking insect as the instrument, and this insect must be common to man and the rat, or at least frequently found on both. This condition is fulfilled by the rat-flea and by no other.

If we make a chart showing the number of plague-infected rats found among the hundreds daily caught and destroyed in the city of Bombay, and compare the curve produced with a similar one made by plotting down the number of human plague deaths during the same period, we shall see a very striking picture.

The curve showing the numbers of infected *M. rattus* will follow that showing the number of human plague deaths with wonderful regularity, but at an interval of ten to fifteen days. This interval is accounted for by the number of days it takes for the fleas to become hungry after the departure of the rats; by the known incubation time of plague in man; and by the average duration of the disease in man.

All these facts have an important bearing on the question of the spread of plague from one place to another. The first Plague Commission said in regard to this point: "In comparison with travellers, all other agencies which have been engaged in the distribution of plague from place to place, are quite unimportant." How do they do it? It is known that fleas fed on man may remain alive for three weeks, and may be infective for fifteen days. There is, therefore, ample time for infective fleas to be transported from one place to another by travellers, on their persons or in their baggage. When the traveller arrives at the end of his journey, he will be in a place where fresh rats abound, and the fleas will naturally desert him for their proper hosts and so start plague among them. Clothes sent by post also may be infective up to a week at least, if they contain fleas.

The importance of the above discoveries, in reference to the measures that should be adopted for the control of this terrible disease, cannot be overestimated. They provide us for the first time with a sure and scientific basis on which to work, and have explained the cause of failure of the well-meaning efforts to combat the disease which were made when plague first appeared. Efforts are now concentrated on the breaking of the chain of events leading from the rat through the flea to man.

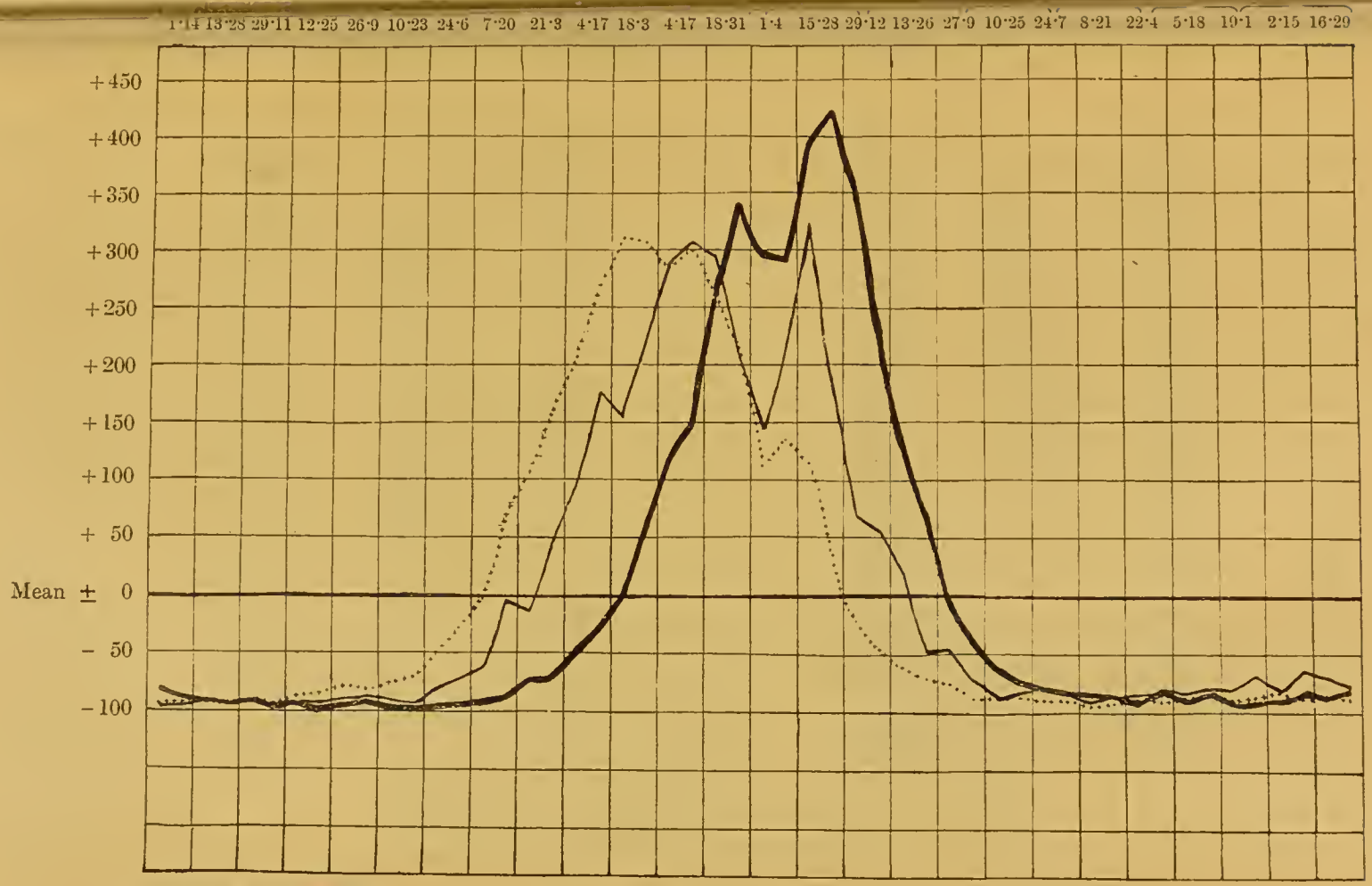


CHART I—Showing the progress of the Plague in Rats and Men.

In India the problem of dealing with rats is infinitely more complex than in England, where they rarely enter houses. In India, on the contrary, the rat, through

Mus rattus. The House Rat.

centuries of consort with man, has become almost a domestic animal. It lives and breeds in rooms and roofs, and picks up its food from the scraps left in or

Mus decumanus. The Sewer Rat.

near the rooms by the people. The rat of India is *Mus rattus* or the old English Black Rat, which used to be the rat of England when plague prevailed there, and

which was banished by the arrival of the brown rat (*Mus decumanus*) from the Continent. It is a clean-living animal and lives in the house with man, not like the filth-loving brown rat which keeps to sewers and underground cellars, and avoids man as far as possible. What is required, then, to break the chain at this point, is a means of separation between rats and man. Well-

A Street in Bombay. A Paradise for Rats.

built houses and a change in the attitude and habits of the people will be necessary to effect this, and only those who have spent their lives in India know the difficulties of the task. A beginning has been made in the larger towns by building solid masonry houses and opening out new suburbs, but the great bulk of the country is untouched by such schemes. The habits of

centuries, and the tenets of a religion that looks on the taking of life as sin, are not easy to overcome, even though the people are convinced that their safety lies that way.

When it was ascertained that the plague germs do not reside in earth or on floors, but only in the bodies of rats or fleas, it was at once realised that the disinfection of houses by means of germ-killing solutions was useless, and attention was turned to the problem of destroying the fleas. The best method of doing this was found out after many experiments had been undertaken, and these pests are now dealt with by emulsions of oil, which are at once cheap and effective.

It will be realised, then, that the problem of the permanent separation of man from the plague rat and its dangerous flea is one that can only very gradually be solved by the erection of proper houses, and, what is even more difficult, the changing of the people's habits, crystallised by centuries of custom. But there is a measure which has become popular in the country districts, and which temporarily effects the purpose, and that is complete evacuation of the village and camping in the fields around. This is an efficient measure where the people resort to it early enough, and where it is carried out voluntarily ; if otherwise, it merely results in spreading the disease far and wide through the agency of fugitives. But the expense, inconvenience, and discomfort entailed in this measure to a people who often carry on trade in their houses can easily be imagined.

Fortunately science has placed in our hands a means by which we may protect people from the ravages of the disease, even though the neighbourhood should be invaded by plague among the rat population. This is

inoculation with the anti-plague vaccine discovered by Mr. Haffkine. The inoculated acquire a high degree of protection, the mortality among them being only about one-sixth of that among the uninoculated under the same conditions.

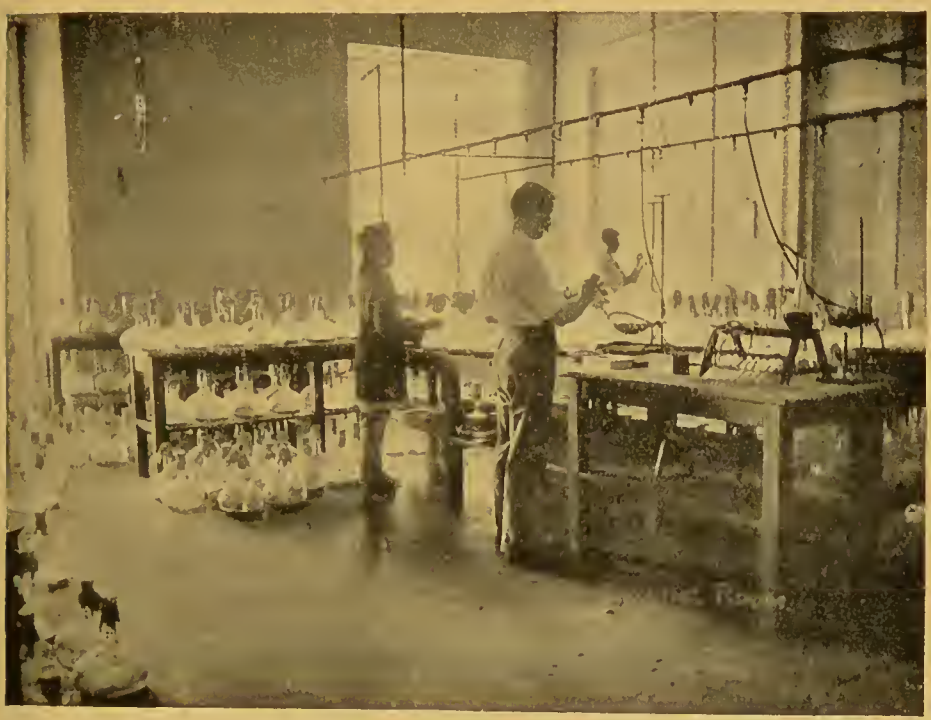
Mr. Haffkine, working in Bombay on the lines laid down by his great master Pasteur, discovered that he could protect rabbits from plague by inoculating them with the dead germs of the disease. The rabbits so rendered immune could not be made to take plague afterwards, as other rabbits easily could. After Mr. Haffkine had tested the harmlessness of an injection of those dead germs on his own person, and on several medical men of Bombay, an outbreak of plague in one of the Bombay jails afforded an opportunity of ascertaining whether such an injection would protect human beings actually threatened with plague. It was found that it does afford protection.

How is such protection brought about? It is common knowledge that most infectious diseases are caused by bacteria, and that each disease is due to the action of a special germ. It is likewise known that in most of such diseases one attack renders a person free from liability to a second attack; the person has become *immune*, as we say. Now how does Nature produce this immunity? The experimental method has shown that bacteria do not act injuriously on account of their numbers in the body, but because they have the power of manufacturing a poison, or "toxin," as it is called, which acts on the body and injures it. When this poison, or toxin, is poured out into the body, the body proceeds to evolve an antidote to the poison; and this is called an "anti-toxin," or anti-poison. If time and strength are granted, the body produces enough

of this anti-toxin to neutralise the toxin and destroy it, and the patient recovers, retaining in his body the power of rapidly producing this anti-toxin, so that any fresh germs of this disease gaining entrance will be at once killed by it and no second illness will ensue. If we can in any way imitate Nature in this process, without producing the disease itself, it is evident that we can protect people from an attack. Can we manufacture this toxin, and introduce it in amounts that will be harmless to the body, and so start the manufacture of the desired anti-toxin? We know from experiment that bacteria produce toxins while they are alive. It is possible to keep them alive while they are doing this, by growing them on an artificial medium, and then, by heat or other means, to kill them so as to make a preparation of lifeless bacteria and their toxins. The germs, being dead, cannot make any more toxin, and the toxin being a lifeless chemical substance cannot increase in amount. If then we take this lifeless preparation and introduce a limited amount of it into the body, it is found that the body will react to it and produce anti-toxin, to neutralise the toxin introduced into it. In this way we can stir up the body to make anti-toxin, without subjecting it to the inconvenience and danger of an attack of the disease itself. It was by similar processes that Pasteur was able to protect sheep against anthrax and fowls against chicken cholera; and it was he who proposed to call all such preparations "vaccines" in honour of Jenner's immortal discovery, though they have nothing whatever to do with the cow.

The anti-plague vaccine (or plague prophylactic) of Mr. Haffkine is made by growing the germs of plague in a broth rendered sterile by heat. After many weeks of

growth, the broth is seen to have become quite thick and turbid from the countless millions of plague germs that have been produced in the previously clear broth. When the proper time arrives, the flask containing this mixture is placed in hot water, so as to heat the contents to such an extent as to kill off all the germs. A small quantity of carbolic acid is added to preserve it, and it

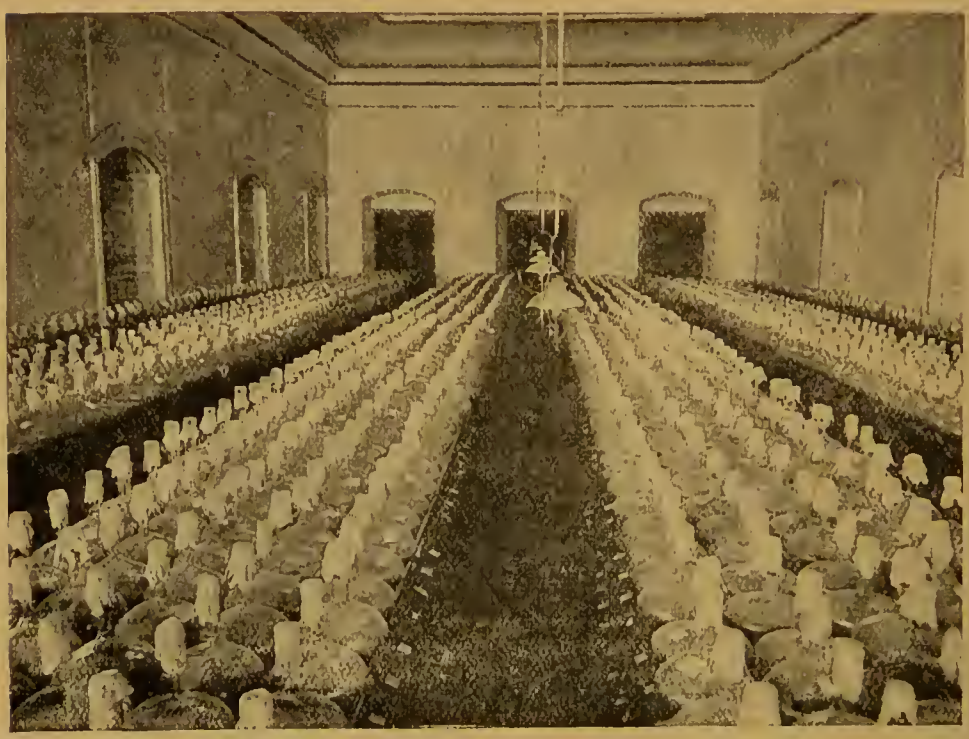


The Sowing and Testing Room.

is then decanted into bottles, which are hermetically sealed. What have we in these bottles? Dead plague germs, the toxin they have made while still alive, and the broth in which they grew. We can then measure the strength of this mixture and regulate the dose so that the amount injected is just enough to start the machinery of the body without doing any harm. In this way people are protected against attacks of plague

just as they would have been by an attack of the disease itself, if they had chanced to survive.

In popularising the plague prophylaetic, the one difficulty that has to be fought against consists in overcoming the popular idea that it is the living virus of plague that is injected. Medical science has to contend sometimes, even in England, against credulous

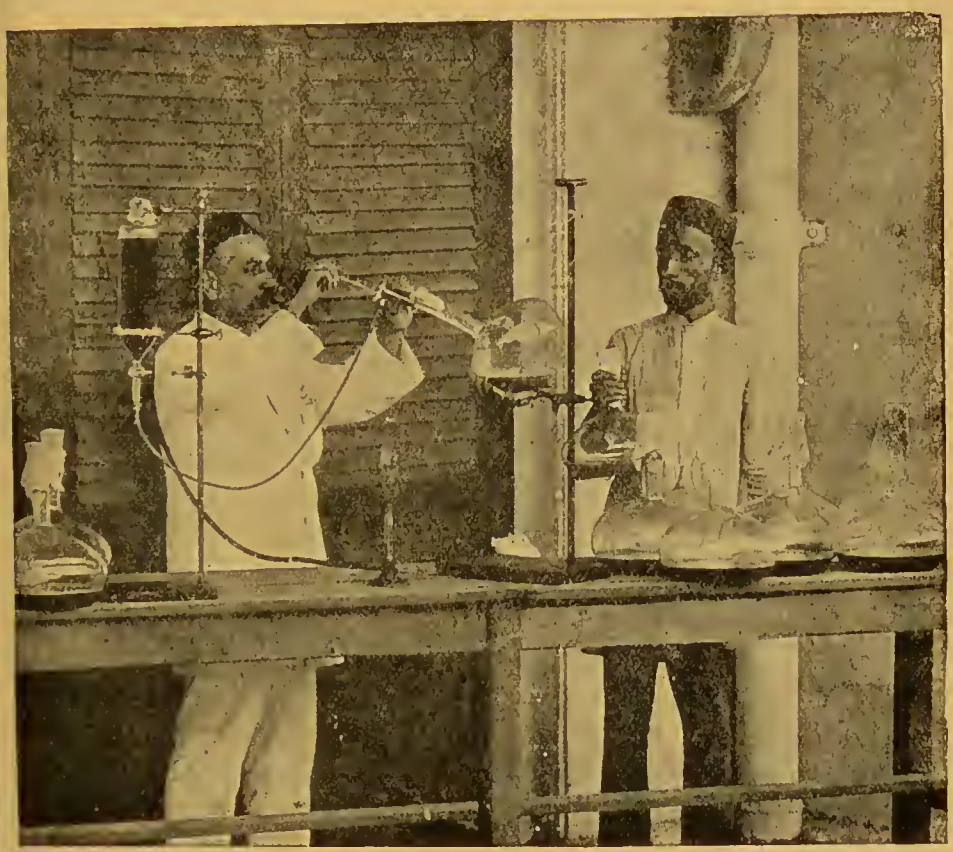


The Incubating Room.

readiness to believe evil of others. What it has to contend with in India may be judged of by the fact that, when inoculation against plague was started in the Punjab, it was popularly believed that the doctors were being sent round to propagate plague, in order that human livers might be available, with which to make a potent drug that could renew the youth of the Empress, whose Diamond Jubilee had recently been celebrated !

Yet in spite of such ideas the total demand for the prophylactic continues slowly to increase; its protective power is found to be so marked wherever it is put to a practical test.

To show what it can do, a few statistics may be quoted from the many examples that year after year are



Sterilising the Vaccine: adding the Carbolic.

reported in India. These will be chosen not because they are more striking than scores of others, but because they have been thoroughly investigated on the spot by thoroughly competent observers.

An epidemic of virulent plague had broken out at Undhera, an agricultural village in Baroda State.

When inoculation was offered to the people, seventy-six had already died of plague in six weeks, with the result that the people gladly accepted any chance of relief held out to them. From the nominal roll of the inhabitants, which had been prepared by the State, it was possible to call out all the dwellers in each house, and of these approximately half were inoculated, care being taken to arrange that an equal number of young and old, strong and feeble, male and female, were placed in each category. Of the 950 inhabitants, 513 were inoculated with the plague prophylactic, the rest being left unprotected.

Plague continued in the village for forty-two days after this, and cases occurred in twenty-eight families. The latter were composed of seventy-one inoculated and sixty-four uninoculated persons. The seventy-one inoculated had eight attacks with three deaths, while the sixty-four not inoculated had twenty-seven attacks with twenty-six deaths.

In a tenement at Pilot Bandar, Bombay, inoculation was carried out two months before plague broke out there. It contained sixty-one persons, twenty-four of whom had been inoculated. Only one of the twenty-four was attacked by plague, and he recovered, while of the thirty-seven not inoculated, nineteen were attacked by the disease and twelve of them died.

The Senior Medical Officer, Belgaum, reports that the men of the Army Hospital Corps, with their families, numbering eighty-three individuals, were living close to the European Military Hospital under constant supervision. All but three submitted to inoculation. After the epidemic was over, it was found that two of the three not inoculated had died of plague, while none of the eighty had suffered in any way.

Another instance, quoted by the same officer, is that of his private servants and their families, most of whom lived in his compound. Those inoculated numbered twenty-eight; those not inoculated two only. Both these latter died, while none of those protected were attacked by plague.

The police in Khandesh were inoculated to the extent

An Assistant-Surgeon Inoculating.

of 1,508, while 230 remained uninoculated. The former had three deaths from plague; the latter had four.

At Hubli 1,260 railway employees were inoculated, and 760 living in the same quarters refused. The former had two deaths among them while the latter had twenty-one.

The manager at the Empress Mills at Nagpur popularised inoculation in his large factory. Among 1,116 inoculated mill-hands there were six deaths from plague, while 2,663 uninoculated workers lost 179 from this disease.

The Medical Officer of Health of Bombay city persuaded a large number of municipal servants who occupied special municipal tenements, and were therefore under easy daily observation, to be inoculated, with the following results. Among 3,317 inoculated there were three deaths from plague, while among 838 who refused to be inoculated there were eighteen deaths.

In Karachi, the Medical Officer pursued a similar course with the town scavengers. He inoculated 1,245, and had four deaths from plague among them during the epidemic season, while among sixty not so protected there were five deaths.

In the Punjab, inoculation is carried out vigorously every year. Here is the record of what took place some years ago. The figures are taken from all those villages in which more than ten per cent. of the inhabitants had been inoculated four months or less before plague appeared in them. These villages contained 186,797 persons who had been inoculated, as compared with 639,630 who had not been inoculated.

Among the inoculated there were 814 deaths from plague.

Among the uninoculated there were 29,623 deaths from plague.

From these figures we may calculate that, roughly speaking, 8,000 lives were saved by inoculation in these villages.

The above instances show a substantial saving of life, which can be estimated in figures: in the case of the

scavengers, for example, the number of lives saved can be shown by a simple calculation to have been a hundred, and in that of the Punjab villages eight thousand.

Examples like these could be multiplied without end, but this appears hardly necessary. Enough has been said to show that thousands of human lives have been saved by the use of this prophylactic, which without experiment on animals would never have been discovered.

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